State Water Resources Control Board

DRAFT

Cannabis Cultivation Policy

Staff Report

Appendix 2
Salmonid Life Histories

October 17, 2017

Table of Contents

List of Figures

1.0 Special-Status[1] Anadromous Salmonids

The streams and rivers of California serve as habitat to 16 special-status anadromous salmonid populations, including Chinook salmon, coho salmon, and steelhead evolutionarily significant units (ESUs), distinct population segments (DPSs), or distinct taxonomic entities[2] (DTEs). This technical appendix discusses the general life history characteristics and the major threats to the viability of each special-status anadromous salmonid ESU, DPS, and DTE in California. Figure 1 is included to aid visualization of life stage timing for each referenced ESU/DPS/DTE. Please note that California's streams and rivers also support other important aquatic and aquatic-dependent species, such as non-anadromous fish populations; however, anadromous salmonids are the focus of this appendix.

1.1 Southern Oregon/Northern California Coastal Chinook Salmon

1.1.1 Status and Distribution

The Southern Oregon/Northern California Coastal (SONCC) Chinook salmon ESU is a special-status species listed as a species of special concern[3] by the California Department of Fish and Wildlife (CDFW). The SONCC Chinook salmon ESU includes Chinook salmon populations in streams from Cape Blanco, Oregon, south to the Klamath River, including Klamath River tributaries from the mouth to the confluence with the Trinity River (Figure 2). SONCC Chinook salmon populations in California include populations in the Smith River and a few lower Klamath River tributaries, including Blue Creek. SONCC Chinook salmon are considered fall-run Chinook salmon based on the population's life-history timing. (Moyle et al. 2015).

1.1.2 Life History

In general, SONCC Chinook salmon rear in freshwater for up to one year, migrate to the ocean, spend one to four years maturing in the marine environment and return to freshwater to spawn. Most SONCC Chinook salmon adults re-enter freshwater in the late fall, when stream flows typically increase, however SONCC Chinook salmon may enter Blue Creek as early as September or as late as December. SONCC Chinook salmon spawning typically begins in October or November and continues into January or February. Most SONCC Chinook salmon

[1] For the purposes of the Cannabis Cultivation Policy, the term "special-status" refers to species or distinct populations that are federally listed as threatened or endangered, listed as threatened or endangered by the state of California, listed as a species of concern by the National Marine Fisheries Service (NMFS), or listed as species of special concern by the California Department of Fish and Wildlife (CDFW). No California salmonids were federally proposed for listing as threatened or endangered or designated as a State Candidate for threatened or endangered listing by the state of California at the time of the preparation of this report (CDFW 2017b). Pink and chum salmon, which are noted as likely species of special concern by Moyle et al., are discussed in section 2.0 of this appendix (2015).

[2] The term "distinct taxonomic entity" (DTE) is applied in this document in reference to salmonid populations given consideration by CDFW as distinct, or separate, taxa, but that are not currently designated as individual ESUs or DPSs by NMFS.

[3] CDFW defines California fish species of special concern to be "those species, subspecies, Evolutionary Significant Unit, or Distinct Population Segment of native fish that currently satisfy one or more of the following (not necessarily mutually exclusive) criteria: are known to spawn in California's inland waters; are not already listed under either federal or state endangered species acts (or both); are experiencing, or formerly experienced, population declines or range retractions that, if continued, could qualify them for listing as threatened or endangered status; [and/or] have naturally small populations exhibiting high susceptibility to risk from stressors that, if realized, could lead to declines that would qualify them for listing as threatened or endangered" (CDFW 2017a).

spawn in the middle reaches of coastal tributaries. As with all salmon, SONCC Chinook salmon spawn only once and die shortly after spawning. (Moyle et al. 2015)

SONCC Chinook salmon eggs incubate in redds for 40 to 60 days before hatching. The newly hatched fish, called alevins, remain in the redds for an additional four to six weeks before emerging into the water column as fry. SONCC Chinook salmon fry emergence occurs in the lower Klamath tributaries between February and mid-April. Some SONCC Chinook fry out-migrate to the ocean within weeks of emergence, while others may rear in freshwater for two months up to more than one year. If stream temperatures remain below 20 degrees Celsius, juvenile SONCC Chinook salmon will continue to rear instream throughout their first summer. A 1995-96 study of Blue Creek found fry outmigration began before mid-March, peaked in late April and late May, and continued into August. An earlier study of returning adults, using scale aging, found that most had reared in freshwater for two to six months as juveniles. Following outmigration, SONCC Chinook salmon generally spend one to four years maturing in the marine environment before returning to freshwater streams to spawn, primarily as three- and four-year-olds (Gale et al. 1998, Moyle et al. 2015).

1.1.3 Threats to Viability

SONCC Chinook salmon are subject to a number of population viability threats. Overall, the threat to the viability of SONCC Chinook salmon population is considered to be of moderate concern. Major anthropogenic factors limiting or potentially limiting SONCC Chinook salmon population viability include: hatcheries, estuary alteration, fisheries harvest, transportation, logging, rural residential development, and grazing. In addition, SONCC Chinook salmon populations may be impacted by climate change, especially as a result of temperature increases, changes to ocean conditions, and sea level rise. Factors of lesser concern that may impact SONCC Chinook salmon populations include major dams, agriculture, fire, recreation, and alien species (Moyle et al. 2015). The most significant threats discussed above that may be exacerbated by cannabis cultivation include: agriculture, existing roads and road development, logging, and rural development.

1.2 California Coastal Chinook Salmon

1.2.1 Status and Distribution

The California Coastal (CC) Chinook salmon ESU is a special-status species, listed as threatened under the federal Endangered Species Act (ESA). The CC Chinook salmon ESU includes Chinook salmon populations located in all coastal watersheds from Redwood Creek in Humboldt County south to the Russian River and its tributaries (Figure 2). The CC Chinook salmon ESU also includes seven artificial propagation programs. (CDFW 2017b)

1.2.2 Life History

The California coastal region historically supported both ocean-type Chinook salmon, which were predominantly fall-run Chinook salmon, and stream-type Chinook salmon, which were predominantly spring-run Chinook salmon. CC spring-run Chinook salmon, which relied on spring and summer snowmelt during adult spawning migration, are presumed to be extirpated likely due to low flows, high water temperatures, and sandbars, which develop in smaller coastal watersheds during the summer months and serve as a barrier to migration. Today, the CC Chinook salmon ESU includes only CC fall-run Chinook salmon. (NMFS 2015)

CC fall-run Chinook salmon have a differently-timed life history than CC spring-run Chinook salmon. In general, CC fall-run Chinook salmon rear in freshwater for a few weeks up to

several months, migrate to the ocean, spend two to five years maturing in the marine environment, and then return to freshwater to spawn in the fall season. (Fall-run adults can produce stream-type progeny, although ocean-type is far more common [NMFS 2015, p. 42, para. 1].) CC fall-run Chinook salmon adults return to freshwater between August and January at an advanced stage of maturity. CC fall-run Chinook salmon move rapidly to their low-elevation spawning grounds on the mainstem or lower tributaries of coastal rivers, and spawn within a few weeks of freshwater entry. As with all salmon, CC Chinook salmon spawn only once, and die shortly after spawning. Female Chinook salmon will guard or defend redds from predators for two to four weeks prior to their deaths. (NMFS 2015)

CC Chinook salmon eggs incubate in redds for 40 to 60 days before hatching, depending on water temperature. The newly hatched alevins remain in the redds for an additional four to six weeks, typically emerging into the water column as fry between December and mid-April. Ocean-type fry of juvenile CC Chinook salmon generally out-migrate to the marine environment within a few weeks to several months after emergence, usually between April and July. A strong environmental cue for the initiation of smoltification, a physiological transformation to prepare the fish for survival in a saline environment, appears to be an increase in water temperature. After out-migrating, CC Chinook salmon generally spend two to five years maturing in the marine environment before migrating back to freshwater to spawn. Some Chinook salmon, termed jacks (males) or jills (females), may return to freshwater to spawn one or more years early. (Moyle 2002, NMFS 2015)

The uncommon stream-type CC Chinook salmon life history differs from the ocean-type in several significant ways. First, stream-type CC Chinook salmon adult spawning migration takes place during spring and summer, typically between April and August, instead of during the fall and early winter months. Second, stream-type CC Chinook salmon adults enter freshwater when sexually immature and hold in cold, headwater tributaries for up to several months to complete maturation prior to spawning during fall. Lastly, stream-type juvenile CC Chinook salmon frequently reside in freshwater for a much longer period of one year or more prior to outmigration. (NMFS 2015)

1.2.3 Threats to Viability

CC Chinook salmon are subject to a number of population viability threats. All CC Chinook salmon life stages are affected by population viability threats, with the greatest impacts falling on adults, followed by pre-smolts, smolts, and eggs. NMFS identified that the highest severity and most extensive threat sources to the CC Chinook salmon, inclusive of all life stages, are: channel modification, roads and railroads, logging and wood harvesting, water diversions and impoundments, and severe weather patterns. Threats of lesser severity or extent include: disease, predation, and competition; livestock farming and ranching; mining; fire, fuel management, and fire suppression; residential and commercial development; agriculture; fishing and collecting; recreational areas and activities; and hatcheries and aquaculture (NMFS 2015). The most significant threats discussed above that may be exacerbated by cannabis cultivation include: agriculture, water diversions and impoundments, channel modification, logging and wood harvesting, and existing roads and road development.

1.3 Klamath Mountains Province Steelhead

1.3.1 Status and Distribution

The Klamath Mountains Province (KMP) steelhead distinct population segment (DPS) is a special-status species, which is listed as a species of special concern by CDFW. The KMP steelhead DPS includes coastal watersheds in northern California and southern Oregon,

spanning the Klamath River watershed in California north to the Elk River watershed in Oregon (Figure 3). (Moyle et al. 2015)

1.3.2 Life History

In general, the KMP steelhead rear in freshwater for two years, migrate to the ocean to spend two to three years maturing in the marine environment, and then return to freshwater to spawn. KMP steelhead exhibit two reproductive ecotypes, termed ocean maturing and stream maturing. Ocean-maturing KMP steelhead enter freshwater when sexually mature. These steelhead are also generally called winter steelhead based on the timing of their spawning migration. Winter steelhead spawning migration typically begins in November, but may begin as early as September, and continues into April. Winter steelhead spawning typically peaks before March. (Moyle et al 2015)

Stream-maturing KMP steelhead enter freshwater while sexually immature and complete their maturation in-river over the course of several months. This reproductive strategy is used by both runs of stream-maturing KMP steelhead: summer steelhead and fall steelhead. Summer steelhead enter freshwater as early as March and continue as late as July, though April to June is typical. KMP summer steelhead spawning begins in late December and peaks in January. Fall steelhead enter the Klamath Basin between July and November and migrate into spawning reaches in the Klamath and Trinity Rivers between August and November. Fall steelhead spawn between January and May. Steelhead are capable of spawning more than once and adult steelhead may survive spawning to migrate back to the ocean and return to freshwater to spawn again in subsequent years. One study found that between 40 to 64 percent of spawning KMP summer steelhead were repeat spawners. (Moyle et al. 2015)

KMP steelhead eggs incubate in redds for 18 to 80 days, depending on water temperature. Upon hatching, the alevins remain in the redds for an additional two to six weeks. In the Trinity River, KMP steelhead fry emerge from their redds beginning in April and migrate downstream from May through July; presumably, KMP steelhead in other rivers and streams within their native range exhibit similar fry emergence timing. If spawned in intermittent streams, as may be the case with summer steelhead, fry move into perennial streams soon after emergence. In late fall and winter, further downstream movement of KMP steelhead fry occurs, coinciding with periods of higher flows and lower water temperatures. The juveniles then spend their second year rearing in the river mainstem. Generally, after spending two years in freshwater, juvenile KMP steelhead out-migrate to the ocean where they continue maturing for one to three years before returning to freshwater to spawn. (Moyle et al. 2015)

A portion of all KMP steelhead variants (i.e., winter, fall, and summer steelhead) exhibit the half-pounder life-history strategy. Under this strategy, subadults, called half-pounders, return to the lower and middle Klamath River in late summer and early fall to overwinter, after having typically spent only two to four months in the Klamath estuary or near-shore environments, before out-migrating back to the ocean the following spring. Only a small portion of half-pounders will attain sexual maturity during this freshwater residency. (Moyle et al. 2015)

1.3.3 Threats to Viability

KMP steelhead are subject to a number of population viability threats. Overall, the threat to the viability of KMP steelhead populations is considered to be of high concern. Stream-maturing steelhead, especially summer steelhead, are particularly vulnerable to near-term extinction (Moyle et al. 2015, KMPS, p. 1, para. 1). Major anthropogenic factors likely contributing to the decline of KMP steelhead include dams, diversions, logging, and agriculture (2015, KMPS, p.

18, para. 3). Climate change is also projected to negatively affect KMP steelhead populations, especially since seasonal water temperatures and flows are already marginal in many areas (2015, p. 24, Table 6). KMP steelhead population viability threats of lesser concern include grazing, transportation, fire, estuary alteration, hatcheries, rural residential development, urbanization, instream mining, hard rock mining, recreation, harvest, and alien species (Moyle et al. 2015, KMPS, p. 22, Table 5). The most significant threats discussed above that may be exacerbated by cannabis cultivation include: diversions, agriculture, existing roads and road development, logging, and rural development.

1.4 Northern California Steelhead

1.4.1 Status and Distribution

The Northern California (NC) steelhead DPS is a special-status species, and is listed as threatened under the federal ESA (CDFW 2017b). The NC steelhead DPS includes steelhead populations in California coastal watersheds, spanning Redwood Creek in Humboldt County south to the Gualala River watershed (Figure 3).

1.4.2 Life History

In general, NC steelhead rear in freshwater for one to four years, migrate to the ocean to spend one to four years maturing in the marine environment, and return to freshwater to spawn. NC steelhead exhibit two reproductive ecotypes, termed ocean-maturing, or winter-run, and stream-maturing, or summer-run (NMFS 2007b). Ocean-maturing (winter-run) NC steelhead adult migration occurs between November and April. Adult winter-run NC steelhead migrate when sexually mature and spawn shortly after freshwater entry (NMFS 2015). The timing of NC steelhead freshwater entry is correlated with higher flow events and, for some populations, sandbar breaches, which can be a barrier to upstream migration (NMFS 2015). In contrast, stream-maturing (summer-run) NC steelhead return to freshwater between May and October while sexually immature. NC summer-run steelhead complete their maturation in freshwater prior to spawning, which typically occurs in January and February (NMFS 2015).

After spawning, NC steelhead may become trapped in freshwater by low spring flows while out-migrating and held until higher flows return in fall. One study found that of adult steelhead trapped in freshwater during the spring season, 40 percent were still alive by late October. Another study found repeat spawners made up about 17 percent of a given year's spawning run. (NMFS 2015)

NC steelhead eggs incubate in redds for approximately 25 to 35 days depending on water temperature. Upon hatching, the alevins remain in the redds for an additional two to three weeks before emerging into the water column as fry. Fry and juvenile NC steelhead freshwater residency varies according to habitat productivity (i.e., the rate of generation of biomass). In productive habitats, such as lagoons or relatively warm streams, juveniles may reach sufficient size to out-migrate after one year. In less productive habitats, such as small coastal streams with dense riparian canopies and low, cool summer baseflows, juvenile NC steelhead typically rear for two or more years before out-migrating. Juvenile NC steelhead outmigration usually occurs in late winter and spring, but NC steelhead populations in the northern portion of the DPS may continue outmigration into the summer months. The process of smoltification, which prepares juvenile steelhead for the saline ocean environment, is triggered by environmental cues, such as an increased water temperature and photoperiod (i.e., day length). (NMFS 2015)

NC steelhead ocean residency varies according to several life history strategies. Following outmigration, steelhead may spend up to four years maturing in the marine environment, though

one or two years is typical. Additionally, NC steelhead populations in the Mad and Eel River watersheds include a half-pounder life history strategy. These half-pounders return from the ocean after only two to four months to overwinter in freshwater and then return to the ocean the following spring. (NMFS 2015)

1.4.3 Threats to Viability

NC steelhead are subject to a number of population viability threats. All NC steelhead life stages are affected by population viability threats, with the greatest impacts occurring to winter-rearing juveniles, followed by summer adults and summer-rearing juveniles (NMFS 2015, Vol. III, p. 52, para. 1). The highest severity and most extensive population viability threat sources to NC steelhead, inclusive of all life stages, are roads and railroads, water diversions and impoundments, logging and wood harvesting, and channel modification (NMFS 2015, Vol. III, p. 62 para. 1). Threats of lesser severity or extent include: severe weather patterns; livestock farming and ranching; disease, predation, and competition; fire, fuel management, and fire suppression; mining; agriculture; fishing and collecting; hatcheries and aquaculture; residential and commercial development; and recreational areas and activities (NMFS 2015, Vol. III, p. 64, Figure 23). The most significant threats discussed above that may be exacerbated by cannabis cultivation include: agriculture, water diversions and impoundments, channel modification, logging and wood harvesting, and existing roads and road development.

1.5 Southern Oregon/Northern California Coast Coho Salmon

1.5.1 Status and Distribution

The Southern Oregon/Northern California Coast (SONCC) coho salmon ESU is a special-status species listed as threatened under the federal ESA and the California ESA (CDFW 2017b). The SONCC coho salmon ESU includes all naturally spawned coho salmon populations in coastal streams north of Punta Gorda, California, and south of Cape Blanco, Oregon (Figure 4). The SONCC coho salmon ESU also includes coho salmon produced by three artificial propagation programs (NMFS 2014a).

1.5.2 Life History

SONCC coho salmon generally adhere to a three-year life cycle. SONCC coho salmon typically rear in freshwater for one year, migrate to the ocean to spend two years maturing in the marine environment, and then return to freshwater to spawn. Adult SONCC coho salmon migration may begin as early as late August, but typically occurs from October to March; peak adult SONCC coho salmon migration occurs between November and January. Adult SONCC coho salmon migration generally coincides with fall high streamflow events that are sufficient to breach sandbars at the mouth of SONCC coho salmon watersheds. SONCC coho salmon spawning grounds are typically located within 240 km of the coast, either along the coast, in small tributaries of larger rivers, or in headwater streams. Females tend to spawn soon after arriving at spawning grounds, usually between November and January; however, SONCC coho salmon may hold for days to months after arriving prior to spawning. As with all salmon, SONCC coho salmon spawn only once, and die shortly after spawning. Female SONCC coho salmon will guard their redds until their deaths, approximately four to 15 days after spawning. (NMFS 2014a)

SONCC coho salmon eggs typically incubate in redds between November and April for approximately 38 to 48 days, depending on water temperature. Upon hatching, alevins remain in the redds for an additional four to 10 weeks, depending on both water temperature and dissolved oxygen conditions, before emerging into the water column as fry. SONCC coho

salmon emergence typically occurs between March and July and peaks in March and May. SONCC coho salmon fry may move upstream or downstream after emergence and may utilize a wide variety of habitat for rearing, including lakes, sloughs, side channels, estuaries, beaver ponds, low gradient tributaries, and large areas of slack water. By about mid-June, SONCC coho salmon fry transition to the juvenile life stage. (NMFS 2014a)

In some basins, juvenile SONCC coho salmon exhibit at least four life-history strategies, which vary according to the timing of outmigration and the duration of riverine or estuarine residency. SONCC coho salmon life history strategies range from immediate outmigration to the estuarine environment following emergence, to rearing primarily in freshwater for up to two years. The dominant SONCC coho salmon life-history strategy involves rearing within natal watersheds for one year prior to out-migrating to the ocean. Some juvenile SONCC coho salmon may exhibit finer-scale habitat switching, such as juvenile SONCC coho salmon that rear in estuaries during spring, summer, and fall, and then return to freshwater upstream to over winter.

SONCC coho salmon juvenile outmigration timing varies from March or earlier in Roach Creek, tributary to the Klamath River, and Ten Mile Creek, tributary to the Eel River, and continues until as late as August on the South Fork Eel River. Typical outmigration appears to occur in spring, between April and June. Depending on the opportunity and the capacity of the estuary, juvenile SONCC coho salmon may spend a few days to a few weeks in estuaries completing smoltification prior to out-migrating to the ocean. Following outmigration, most SONCC coho salmon spend approximately 18 months in the ocean before returning to their natal streams to spawn as three-year olds; however, some males, called jacks, may return to freshwater to spawn after only five to seven months. (NMFS 2014a)

1.5.3 Threats to Viability

SONCC coho salmon are subject to a number of population viability threats. These population viability threats collectively affect all stages of the SONCC coho salmon life cycle; however, NMFS identifies juvenile SONCC coho salmon to be the most limited life stage[4]. The highest severity and most extensive threat sources to the SONCC coho salmon in California identified by NMFS, inclusive of all life stages, are[5]: roads, channelization and diking, dams and diversions, climate change, timber harvest, and agricultural practices. Threats of lesser severity or extent include: high severity fire; invasive, non-native, and alien species; road stream crossing barriers; urban, industrial, and residential development; hatcheries; mining and gravel extraction; and fishing and collecting (NMFS 2014a). The most significant threats discussed above that may be exacerbated by cannabis cultivation include: agricultural practices, dams and diversions, channelization and diking, timber harvest, roads, and roads stream crossing barriers.

1.6 Upper Klamath-Trinity Rivers Spring-Run Chinook Salmon

1.6.1 Status and Distribution

The Upper Klamath-Trinity Rivers spring-run (UKTR SR) Chinook salmon DTE is listed as a species of special concern by CDFW. UKTR SR Chinook salmon are found in the Klamath River watershed, in major tributaries above the confluence of the Klamath and Trinity Rivers (Figure 2). Although all naturally spawned populations of Chinook salmon in the Klamath River

[4] The SONCC coho salmon ESU includes the following watersheds that have no territory within the state of California: Elk River, Lower Rogue River, Chetco River, Brush Creek, Mussel Creek, Hunter Creek, Pistol River, and Upper Rogue River (NMFS 2014a).

[5] Population viability threats listed here consider only those stream systems that have at least some of their territory within the state of California.

basin are included in the Upper Klamath-Trinity Rivers (UKTR) Chinook salmon ESU, CDFW treats UKTR SR Chinook salmon as a distinct taxon, because this population represents an essential UKTR Chinook salmon life-history strategy, and separate management strategies compared to UKTR fall-run Chinook salmon. (Moyle et al. 2015)

1.6.2 Life History

In general, UKTR SR Chinook salmon rear in freshwater for up to one year, migrate to the ocean, spend two to five years maturing in the marine environment, and return to freshwater to spawn. UKTR SR Chinook salmon enter the Klamath River estuary between March and July, while they are sexually immature. Peak UKTR SR Chinook salmon adult migration occurs between May and early June. UKTR SR Chinook salmon generally hold in cold water streams for two to four months and spawn in September and October. As with all salmon, UKTR SR Chinook salmon spawn only once, and die shortly after spawning. (Moyle et al. 2015)

UKTR SR Chinook salmon eggs incubate in redds for 40 to 60 days under optimal egg incubation conditions. Upon hatching, the alevins remain in the redds for an additional four to six weeks. UKTR SR Chinook salmon fry emerge from their redds during the fall, winter, and spring months. UKTR SR Chinook salmon fry emergence begins as early as November in the Trinity River and December in the Klamath River, and can last until late May. UKTR SR Chinook salmon fry generally spend less than one year rearing in freshwater before migrating to the ocean, which typically occurs from February through mid-June. Following outmigration, UKTR SR Chinook salmon generally spend one to four years maturing in the marine environment before returning to freshwater to spawn, primarily as three- and four-year-olds. (Moyle et al 2015)

1.6.3 Threats to Viability

UKTR SR Chinook salmon are subject to a number of population viability threats. Overall, the threat to the viability of UKTR SR Chinook salmon populations is considered to be of critical concern. Major anthropogenic factors limiting or potentially limiting UKTR SR Chinook salmon population viability include major dams, logging, and hatcheries. Wild UKTR SR Chinook salmon populations are also highly vulnerable to climate change and poaching. UKTR SR Chinook salmon population viability threats of lesser concern include agriculture, grazing, instream mining, transportation, harvest, rural residential development, fire, mining, recreation, urbanization, estuary alteration, and alien species (Moyle et al. 2015). The most significant threats discussed above that may be exacerbated by cannabis cultivation include: agriculture, logging, existing roads and road development, and rural development.

1.7 Upper Klamath-Trinity Rivers Fall-Run Chinook Salmon

1.7.1 Status and Distribution

The Upper Klamath-Trinity Rivers fall-run (UKTR FR) Chinook salmon DTE is listed as a species of special concern under the California ESA. UKTR FR Chinook salmon are found in the Klamath River watershed, in major tributaries above the confluence of the Klamath and Trinity Rivers (Figure 2). UKTR FR Chinook salmon along with UKTR SR Chinook salmon constitute a single ESU; however, CDFW treats the two runs as separate taxa because the two runs exhibit distinct life history strategies. (Moyle et al. 2015)

1.7.2 Life History

In general, UKTR FR Chinook salmon rear in freshwater for up to one year, migrate to the ocean, spend two to five years maturing in the marine environment, and return to freshwater to

spawn. UKTR FR Chinook salmon typically enter the Klamath River estuary beginning in early July through September and hold in the estuary for a few weeks before initiating further upstream migration between mid-July and October. UKTR FR Chinook salmon spawning peaks during November in most Klamath and Trinity River tributaries and tapers off in December; in the Trinity River watershed, UKTR FR Chinook salmon spawning typically peaks four to six weeks after UKTR SR Chinook spawning. As with all salmon, UKTR FR Chinook salmon spawn only once, and die shortly after spawning. (Moyle et al. 2015)

UKTR FR Chinook salmon eggs incubate in redds for 40 to 60 days under optimal egg incubation conditions. Upon hatching, the alevins remain in redds for an additional four to six weeks. UKTR FR Chinook salmon fry typically emerge from redds in late winter or spring, depending on water temperatures. (Moyle et al. 2015)

There are at least four distinct juvenile UKTR FR life history strategies. The most predominant juvenile life history strategy is characterized by a short period of freshwater residence, during which fry forage in freshwater streams, followed by outmigration to the ocean during summer. The next most common juvenile life history strategy is characterized by a longer period of freshwater residence, during which fry rear in tributaries or cool-water areas through summer, followed by outmigration during fall to mid-winter. A small portion of UKTR FR Chinook salmon fry rear for an entire year in freshwater before out-migrating to the ocean in the spring. A fourth life history variation in which males rear to maturity in freshwater has also recently been described. Following outmigration, UKTR FR Chinook salmon generally spend one to four years maturing in the marine environment before returning to freshwater to spawn, primarily as three- and four-year-olds. (Moyle et al 2015)

1.7.3 Threats to Viability

UKTR FR Chinook salmon are subject to a number of population viability threats. Overall, the threat to the viability of UKTR FR Chinook salmon populations is considered to be of moderate concern. Major anthropogenic factors limiting or potentially limiting UKTR FR Chinook salmon population viability include: major dams; and agriculture, including water diversions, warm water temperature, and pollutant inputs. UKTR FR Chinook salmon population viability threats of lesser concern include logging, hatcheries, grazing, instream mining, transportation, harvest, rural residential development, fire, mining, recreation, urbanization, estuary alteration, and alien species (Moyle et al. 2015). The most significant threats discussed above that may be exacerbated by cannabis cultivation include: agriculture, logging, existing roads and road development, warm water temperature, pollutant inputs, and rural development.

1.8 Sacramento River Winter-Run Chinook Salmon

1.8.1 Status and Distribution

The Sacramento River winter-run (SRWR) Chinook salmon ESU is a special-status species listed as endangered under the federal ESA and the California ESA (CDFW 2017b). Historically, SRWR Chinook salmon spawned in the cold, spring-fed tributaries of the upper Sacramento River Basin. SRWR Chinook salmon spawning is now restricted to the stretches of the Sacramento River downstream of Keswick Dam, a complete barrier to upstream SRWR Chinook salmon migration (Figure 5). The SRWR Chinook salmon ESU also includes fish that are propagated at the Livingston Stone National Fish Hatchery.

1.8.2 Life History

In general, SRWR Chinook salmon rear in freshwater for 5 to 10 months, migrate to the ocean, spend one to three years maturing in the marine environment, and then return to freshwater to spawn. SRWR Chinook salmon adult upstream migration typically begins in December and lasts through July, and peak migration occurs between February and April (CDFW 2015). SRWR Chinook salmon are sexually immature when upstream migration begins, and SRWR Chinook salmon must hold for several months in suitable freshwater habitat prior to spawning to complete maturation (NMFS 2014b). Historically, SRWR Chinook salmon spawned in the cold, spring-fed tributaries of the upper Sacramento River Basin; however, with the construction of the Keswick Dam, SRWR Chinook salmon migration and spawning are now restricted to the stretches of the Sacramento River downstream of the dam. Spawning now occurs primarily in the mainstem of the Sacramento River between Keswick Dam and Battle Creek, with the majority of spawning occurring in the 14 miles between the Keswick Dam and the Redding Water Treatment Plant. SRWR Chinook salmon spawning typically occurs between April and August and peaks in May and June (CDFW 2015). As with all salmon, SRWR Chinook salmon spawn only once, and die shortly after spawning.

Because SRWR Chinook salmon spawning occurs during late spring and summer months, SRWR Chinook salmon require stream reaches with cold water sources that will protect embryos and juveniles from warm ambient conditions. Within the appropriate egg incubation temperature range, eggs incubate for 40 to 60 days. Upon hatching, SRWR Chinook salmon alevins remain in redds for an additional four to six weeks before emerging into the water column as fry, usually between mid-June and mid-October. Upon emergence, SRWR Chinook salmon fry may immediately begin migration downstream until reaching the San Francisco Bay/Sacramento – San Joaquin Delta (Bay-Delta) estuary, or may reside in freshwater for several weeks or up to one year. Typically, after five to nine months in fresh or estuarine waters, juvenile SRWR Chinook salmon migrate to the ocean; migration between the Bay-Delta and the ocean usually occurs between January and June. Following outmigration, SRWR Chinook salmon typically spend one to three years maturing in the marine environment before migrating back to freshwater to spawn. (NMFS 2014b)

1.8.3 Threats to Viability

SRWR Chinook salmon are subject to a number of population viability threats. SRWR Chinook salmon population stressors collectively affect all life history stages. Major SRWR Chinook salmon stressors include: passage impediments and barriers; flow fluctuations, water pollution, and warm water temperatures; loss of juvenile rearing habitat (e.g., lost natural river morphology and function, and lost riparian habitat and instream cover); predation; ocean harvest; changes in Delta hydrology, diversion into the central Delta, and entrainment of juveniles at pumping plants (NMFS 2014b). The most significant threats discussed above that may be exacerbated by cannabis cultivation include: loss of juvenile rearing habitat, flow fluctuations, water pollution, passage impediments and barriers, warm water temperatures, predation, and entrainment.

1.9 Central Valley Spring-Run Chinook Salmon

1.9.1 Status and Distribution

The Central Valley spring-run (CV SR) Chinook salmon ESU is a special-status species listed as threatened under the federal ESA and the California ESA (CDFW 2017b). The CV SR Chinook salmon ESU contains naturally spawning populations in the Sacramento River watershed, and also includes the Feather River Hatchery Spring-run Chinook Program (Figure 5). Historically, CV SR Chinook salmon populations also occurred in the San Joaquin River

watershed; however, CV SR Chinook salmon have been extirpated from all tributaries in the San Joaquin River watershed. (SWRCB 2010; NMFS 1998)

1.9.2 Life History

In general, CV SR Chinook salmon rear in freshwater for up to 16 months, migrate to the ocean, spend one to four years maturing in the marine environment, and return to freshwater to spawn. CV SR Chinook salmon adult migration into the Delta typically begins in late January and early February, when the fish are sexually immature. Between March and October, adult CV SR Chinook salmon typically continue to migrate upstream into the freshwater of the Sacramento River watershed, peaking between April and July. CV SR Chinook salmon then hold in freshwater for several months in cold, deep pools to complete maturation prior to spawning. CV SR Chinook salmon spawning in the Sacramento River watershed typically occurs between mid-August and early October, with a peak in September. As with all salmon, CV SR Chinook salmon spawn only once, and die shortly after spawning. (CDFS 2015; NMFS 2014b)

CV SR Chinook salmon eggs tend to incubate in redds for 40 to 60 days, typically between August and December, before hatching. CV SR Chinook salmon egg incubation typically occurs between August and December, and fry emergence typically occurs between November and March. Upon emergence, the newly hatched alevins remain in redds for an additional four to six weeks before emerging into the water column as fry, with emergence typical between November and March. In the winter or spring and within eight months of hatching, CV SR Chinook salmon fry may either migrate to the ocean as young-of-the-year, or may rear in freshwater for 12 to 16 months and then migrate to the ocean as yearlings. The specific timing of young-of-the-year and yearling outmigration varies by stream system; outmigration typically occurs between November and May. Following outmigration, CV SR Chinook salmon generally spend one to four years maturing in the marine environment before migrating back to freshwater to spawn, typically as three year olds. (CDFW 2015; NMFS 2014b)

1.9.3 Threats to Viability

CV SR Chinook salmon are subject to a number of population viability threats. These stressors collectively affect all CV SR Chinook salmon life history stages. Major stressors on the CV SR Chinook salmon populations include passage impediments and barriers, ocean harvest, warm water temperatures during holding and rearing periods, limited quantity and quality of rearing habitat (e.g., loss of floodplain habitat, loss of natural river morphology and function, and loss of riparian habitat and instream cover), predation, and entrainment. Other important stressors on CV SR Chinook salmon populations include hatchery effects, warm water temperatures affecting adult immigration and spawning, low-flow conditions, excessive channel braiding, limited spawning habitat availability and instream gravel supply, sedimentation, loss of channel connectivity, and flow fluctuations from hydropower operations (NMFS 2014b). The most significant threats discussed above that may be exacerbated by cannabis cultivation include: limitation to the quantity and quality of rearing habitat, sedimentation, flow fluctuations, low-flow conditions, loss of channel connectivity, warm water temperatures, predation, and entrainment.

1.10 Central Valley Fall-Run Chinook Salmon

1.10.1 Status and Distribution

The Central Valley fall-run (CV FR) Chinook salmon DTE is listed as a species of special concern by CDFW (Moyle et al. 2015). In addition, NMFS lists CV FR Chinook salmon in

conjunction with the Central Valley late fall-run Chinook salmon as a species of concern[6,7] (NMFS 2017).

The CV FR Chinook salmon ESU includes populations in the Sacramento River watershed and the San Joaquin River watershed (Figure 6). Historically, CV FR Chinook salmon spawned in the low elevation reaches of all major Central Valley rivers. Today, impassable dams prevent CV FR Chinook salmon from reaching over seventy percent of their historic spawning habitat. In some Central Valley rivers, however, cold water releases from dams allow CV FR Chinook salmon to spawn in areas where stream temperatures conditions were historically unsuitable to support CV FR Chinook salmon. In addition, CV FR Chinook salmon populations have not been as substantially impacted by dam construction as SRWR Chinook salmon and CV SR Chinook salmon populations, which typically spawn at higher elevations in the Central Valley. (Moyle et al 2015)

1.10.2 Life History

In general, CV FR Chinook salmon rear in freshwater for one to seven months, migrate to the ocean, spend two to five years maturing in the marine environment, and return to freshwater to spawn. CV FR Chinook salmon adult spawning migration typically begins in June and lasts through December, with peak migration occurring between September and October. CV FR Chinook salmon exhibit an ocean-type life-history strategy, are sexually mature when adult upstream migration begins, and move relatively quickly to their spawning grounds. CV FR Chinook salmon spawning typically occurs between late September and December and peaks in October and November. As with all salmon, CV FR Chinook salmon spawn only once, and die shortly after spawning. (Moyle et al. 2015)

CV FR Chinook salmon eggs incubate in redds for 40 to 60 days under optimal egg incubation conditions. Upon hatching, the alevins remain in the redds for an additional four to six weeks before emerging into the water column as fry. CV FR Chinook salmon fry typically emerge between December and March and move downstream into large rivers within a few weeks of emergence. CV FR Chinook salmon fry often rear in freshwater for one to seven months, although they may remain as long as one year before out-migrating. Juvenile CV FR Chinook salmon out-migrate to the ocean during the spring, before water temperatures exceed thermal tolerances during the hot summer and early fall months. Following outmigration, CV FR Chinook salmon typically spend two to five years maturing in the marine environment before migrating back to freshwater to spawn. (Moyle et al. 2015)

Historically, juvenile CV FR Chinook salmon likely foraged extensively on floodplains prior to entering the San Francisco Estuary. This floodplain rearing life history component represented an important growth opportunity for CV FR Chinook salmon, which usually enter the ocean at a relatively small size and young age compared to out-migrating smolts from other Central Valley Chinook salmon runs. Today, less than 10 percent of this historic floodplain habitat remains. Moyle et al 2015)

[6] NMFS designates populations as species of concern if the organization has "concern regarding status and threats, but for which insufficient information is available to indicate a need to list the species under the Endangered Species Act" (NMFS 2017).

[7] NMFS currently considers the Central Valley fall-run Chinook salmon and the Central Valley late fall-run Chinook salmon to be two races under a single ESU. To contrast, CDFW regards the CV FR Chinook salmon and CV LFR Chinook salmon runs as separate taxonomic entities, and thus separate species of special concern on the statewide Species of Special Concern list, based upon their distinct life-history strategies and in consideration of the unique management concerns of each run. (Moyle et al. 2015).

1.10.3 Threats to Viability

CV FR Chinook salmon are subject to a number of population viability threats. Overall, CV FR Chinook salmon population viability threats are considered to be of high concern. Estuary alteration is recognized as the anthropogenic factor of greatest concern related to CV FR Chinook salmon population viability. Additional anthropogenic factors that are considered major concerns on the continued viability of CV FR Chinook salmon populations include: major dams; agriculture; urbanization; instream mining; ocean and inland harvest; and hatcheries. CV FR Chinook salmon are particularly dependent on hatchery production to augment low numbers of naturally-spawning CV FR Chinook salmon, which may result in a loss of CV FR Chinook salmon life history variability due to homogenization. CV FR Chinook salmon viability is also threatened by climate change, which may result in Central Valley stream temperature increases and changes in precipitation patterns. Factors of lesser concern on the continued viability of CV FR Chinook salmon populations include grazing, rural residential development, legacy effects of hydraulic and hard rock gold mining, transportation, logging, fire, recreation, and alien species (Moyle et al 2015). The most significant threats discussed above that may be exacerbated by cannabis cultivation include: agriculture, rural development, logging, and existing roads and road development.

1.11 Central Valley Late Fall-Run Chinook Salmon

1.11.1 Status and Distribution

The Central Valley late fall-run (CV LFR) Chinook salmon DTE is listed as a species of special concern by CDFW (Moyle et al. 2015). In addition, NMFS lists CV LFR Chinook salmon in conjunction with the Central Valley fall-run Chinook salmon as a species of concern[8]. (NMFS 2017)

The CV LFR Chinook salmon ESU includes populations in the Sacramento River watershed (Figure 6). CV LFR Chinook salmon likely historically spawned in the upper Sacramento and McCloud Rivers, in portions of major tributaries that naturally provided adequate cold water temperatures during summer, and possibly in the Friant region and in other large tributaries to the San Joaquin River. Today, impassible dams prevent CV LFR Chinook salmon from reaching much of this historic spawning habitat. As a result, CV LFR Chinook salmon now primarily spawn and rear in the Sacramento River between the Red Bluff Diversion Dam and Redding, and are reliant on cold water releases from Shasta Dam to maintain suitable spawning habitat conditions. (Moyle et al 2015)

1.11.2 Life History

In general, CV LFR Chinook salmon rear in freshwater for 7 to 13 months, migrate to the ocean, spend one to four years maturing in the marine environment, and return to freshwater to spawn. CV LFR Chinook salmon adult migration typically occurs during December and January, but may begin as early as October and continue into April. CV LFR Chinook salmon are sexually mature when upstream migration begins, move relatively quickly to their spawning grounds, and typically spawn shortly after arrival at spawning grounds. CV LFR Chinook salmon spawning occurs between late December and April and peaks between February and March. As with all

[8] NMFS currently considers the Central Valley fall-run Chinook salmon and the Central Valley late fall-run Chinook salmon to be two races under a single ESU. In contrast, CDFW regards the runs as separate taxonomic entities, and thus separate species of special concern on the statewide Species of Special Concern list, based upon their distinct life-history strategies and in consideration of the unique management concerns of each run. (Moyle et al. 2015).

salmon, CV LFR Chinook salmon spawn only once, and die shortly after spawning. (CDFW 2015; Moyle et al 2015)

CV LFR Chinook salmon life history details are less extensively documented compared to other Central Valley Chinook salmon populations because CV LFR Chinook salmon were recognized relatively recently as a unique run[9] and because CV LFR Chinook salmon migration and spawning activities are difficult to observe and tend to coincide with high, cold, and turbid streamflows. It is presumed that CV LFR Chinook salmon have similar egg and alevin incubation lengths compared to other Central Valley Chinook salmon populations; it is presumed that CV LFR Chinook salmon egg incubation lasts for, 40 to 60 days and CV LFR Chinook salmon alevin incubation lasts 4-6 weeks. Alevins typically emerge into the water column as fry from April to early June. Juvenile CV LFR Chinook salmon usually hold in freshwater for 7 to 13 months before out-migrating, and peak CV LFR Chinook salmon outmigration appears to occur in October. Juvenile CV LFR Chinook salmon may, however, out-migrate at younger ages and smaller sizes during most months of the year. Following outmigration, CV LFR Chinook salmon may spend between one and four years maturing in the marine environment before migrating back to freshwater to spawn. Historically, spawning CV LFR Chinook salmon adults consisted of a mix of age classes ranging from two to five years of age; however, currently, most adults return to freshwater to spawn as three-year-olds. (Moyle et al. 2015)

1.11.3 Threats to Viability

CV LFR Chinook salmon are subject to a number of population viability threats. Overall, threats to the viability of CV LFR Chinook salmon population are considered to be of high concern. Major anthropogenic factors limiting or potentially limiting CV LFR Chinook salmon population viability include major dams, estuary alteration, agriculture, ocean and inland harvest, and hatcheries. In addition, while the current proportion of the spawning population of hatchery origin is small, the influence of hatcheries is still of concern due to the associated potential ecological and genetic impacts to the sustainability of the run. CV LFR Chinook salmon face additional risks posed by climate change, which is expected to increase instream temperatures while simultaneously limiting the ability to maintain a cool water pool behind Shasta Dam; these factors may result in a lack of cold water habitat sufficient to support CVLFR Chinook salmon year-round. CV LFR Chinook salmon population viability threats of lesser concern include grazing, rural residential development, instream mining, mining (particularly from Iron Mountain Mine), transportation, logging, fire, recreation, and alien species (Moyle et al. 2015). The most significant threats discussed above that may be exacerbated by cannabis cultivation include: agriculture, rural development, logging, and existing roads and road development.

1.12 California Central Valley Steelhead

1.12.1 Status and Distribution

The California Central Valley (CCV) steelhead DPS is a special-status species listed as threatened under the federal ESA. The CCV steelhead DPS includes naturally spawned steelhead populations in the Sacramento and San Joaquin Rivers and their tributaries, but does not include steelhead populations in tributaries to the San Francisco and San Pablo Bays (Figure 3). The CCV steelhead DPS also includes steelhead from two artificial propagation programs. (CDFW 2017b)

[9] Central Valley late-fall run Chinook salmon were recognized as a distinct Chinook salmon run in 1966, after the construction of the Red Bluff Diversion Dam allowed for easier observation of fish passage through this area (Moyle et al. 2015).

1.12.2 Life History

In general, CCV steelhead rear in freshwater for one to three years, migrate to the ocean, spend one to four years maturing in the marine environment, and return to freshwater to spawn. At this time, CCV steelhead follow an ocean-maturing, or winter run life history strategy, but CCV steelhead may have also historically included a summer steelhead life history strategy prior to the construction of large Central Valley dams. CCV steelhead adults typically begin migrating from the ocean in December when tributary streamflows are high, with peak CCV steelhead adult migration occurring in January and February. However, adult CCV steelhead freshwater migration may begin as early as August and extend until as late as April. CCV steelhead spawn in small streams and tributaries in the Sacramento and San Joaquin River watersheds where cool, well-oxygenated water is available year-round, including every major tributary downstream of major storage dams. CCV steelhead spawning usually occurs between January and March and peaks in February. CCV steelhead are capable of spawning more than once, but rarely spawn more than twice. Those individuals that do not die after spawning typically migrate back to the ocean between April and June, with a peak observed in May. (CDFW 2015; NMFS 2014b)

CCV steelhead eggs incubate in redds for three to four weeks or more, depending on water temperature. Upon hatching, the alevins remain in redds for an additional four to six weeks before emerging into the water column as fry. Fry and juvenile CCV steelhead spend up to three years rearing in freshwater and most commonly rear in freshwater for two years. Typically, juvenile CCV steelhead out-migrate to the ocean between November and May. However, in the Sacramento River watershed, juvenile CCV steelhead may migrate downstream during most months of the year, with peak outmigration occurring in spring, and a smaller peak occurring in fall. During outmigration, juvenile CCV steelhead may rear for short periods in the Delta's tidal marshes, non-tidal freshwater marshes, and other shallow water habitat. Peak outmigration through the Delta typically occurs in March and April. Following outmigration, CCV steelhead typically spend two or three years maturing in the marine environment before migrating back to freshwater to spawn as four- or five-year-olds. (NMFS 2014b; CDFW 2015)

1.12.3 Threats to Viability

CCV steelhead are subject to a number of population viability threats. Overall, stressors on CCV steelhead collectively affect all life history stages. Major stressors on CCV steelhead include passage impediments and barriers, warm water temperatures for rearing, hatchery effects, limited quantity and quality of rearing habitat (e.g., loss of floodplain habitat, loss of natural river morphology and function, and loss of riparian habitat and instream cover), predation, and entrainment. Other important stressors on CCV steelhead include warm water temperatures affecting adult immigration and holding and embryo incubation, limited spawning habitat availability, limited instream gravel supply, sedimentation, the potential for hazardous spills, flow fluctuations, low-flow conditions, and poor water quality (NMFS 2014b). The most significant threats discussed above that may be exacerbated by cannabis cultivation include: limitations to the quantity and quality of rearing habitat, poor water quality, entrainment, sedimentation, flow fluctuations, passage impediments and barriers, predation, warm water temperatures for rearing, and low-flow conditions.

1.13 Central California Coast Steelhead

1.13.1 Status and Distribution

The Central California Coast (CCC) steelhead DPS is a special-status species listed as threatened under the federal ESA. The CCC steelhead DPS includes all steelhead populations from the winter-run populations in the Russian River basin south to Aptos Creek in Santa Cruz County, and the drainages of San Francisco, San Pablo, and Suisun Bays, including the tributary streams to Suisun Marsh, but excluding the Sacramento-San Joaquin River system (Figure 3; CDFW 2017b, NMFS 1996).

1.13.2 Life History

The CCC steelhead DPS exhibits a similar life history to the ocean-maturing, or winter-run, NC steelhead. (NMFS 2011, 2007a) Please refer to the NC steelhead description in this appendix for general life history information that applies to the CCC steelhead DPS.

1.13.3 Threats to Viability

CCC steelhead are subject to a number of population viability is threats. All CCC steelhead life stages are affected by CCC steelhead population viability threats, but the greatest impact of these threats fall on winter-rearing juvenile CCC steelhead, followed by egg incubation and summer-rearing juvenile life history stages. The highest severity and most extensive CCC steelhead population viability threats, inclusive of all life stages, include channel modifications, residential and commercial development, roads and railroads, and water diversions and impoundments. CCC steelhead population viability threats of lesser severity or extent include: severe weather patterns; agriculture; mining; livestock farming and ranching; fire, fuel management, and fire suppression; recreational areas and activities; logging and wood harvesting; disease, predation, and competition; fishing and collecting; and hatcheries and aquaculture (NMFS 2015). The most significant threats discussed above that may be exacerbated by cannabis cultivation include: agriculture, water diversions and impoundments, channel modifications, land development, logging and wood harvesting, and existing roads and road development.

1.14 Central California Coast Coho Salmon

1.14.1 Status and Distribution

The Central California Coast (CCC) coho salmon ESU is a special-status species listed as endangered under the federal ESA and the California ESA (CDFW 2017b). The CCC coho salmon ESU includes all coho salmon populations in California found in coastal watersheds between Punta Gorda in Humboldt County and Aptos Creek in Santa Cruz County (Figure 4; NMFS 2012a).

1.14.2 Life History

CCC coho salmon predominantly adhere to a three-year life cycle. CCC coho salmon typically rear in freshwater for one year, migrate to the ocean, spend two years maturing in the marine environment, and return to freshwater to spawn. Adult CCC coho salmon typically migrate from the ocean to freshwater spawning grounds between September and January and spawn shortly thereafter, typically between November and January. In more southern portions of the CCC coho salmon range, such as Scott and Waddell Creeks in Santa Cruz County, CCC coho salmon tend to migrate and spawn later in the year. This southern-range spawning migration typically occurs from November through January, with spawning occurring into February and early March. CCC coho salmon adult migration into freshwater coincides with large increases in

streamflows that are sufficient to breach sandbars at the mouths of coastal streams and allow salmon access to upstream spawning areas. After spawning, female coho salmon will guard their redds from predators until they become too weak to hold their position. Both male and female coho salmon die shortly after spawning. (Moyle 2002, NMFS 2012a)

CCC coho salmon eggs incubate in redds for approximately 35 to 50 days, between November and April. Upon hatching, the alevins remain in redds for an additional 2 to 10 weeks before emerging into the water column as fry. Juvenile CCC coho salmon emergence typically occurs between February and June and peaks between March and May. Almost all juvenile CCC coho salmon rear in freshwater for one year prior to outmigration. During winter months, juvenile CCC coho salmon may seek refuge from higher flows in off-channel habitat, backwater pools, or small, clear tributaries. Juvenile CCC coho salmon outmigration typically begins in March and peaks from April to July. Most CCC coho salmon spend two years in the marine environment and then migrate to freshwater to spawn as three-year olds. (NMFS 2012a)

Compared to other anadromous salmonid populations in California, CCC coho salmon use the broadest diversity of freshwater/estuarine habitats. These freshwater habitat types include small tributaries of coastal streams, lakes, inland tributaries of major rivers, and estuarine environments. CCC coho salmon may utilize estuarine environments for seasonal juvenile rearing, to transition to or from the more saline ocean environment, or simply as a migratory corridor. (NMFS 2012a)

The dominance of the three-year life cycle amongst CCC coho salmon results in a strong demographic separation of the three-year classes. Exceptions to the dominant life cycle include smolts that remain in freshwater for two years instead of one year and jack males, which may return to freshwater at two years of age after spending only six months spent maturing in the ocean. However, essentially all wild female coho salmon spawn as three-year olds, creating three distinct, separate maternal brood year lineages for each CCC coho salmon stream. The lack of overlapping maternal generations places brood year lineages at high long-term risk from adverse effects of stochastic (random) events. In streams south of San Francisco Bay, loss of year classes appears to have already taken place due to poor ocean conditions and a fire that degraded both riparian and instream habitat. (NMFS 2012a)

1.14.3 Threats to Viability

CCC coho salmon are subject to a number of population viability threats. The most impacted CCC coho salmon life stage is winter-rearing juveniles, but all other life history stages are also impacted by anthropogenic stressors. The highest severity and most extensive CCC coho salmon population viability threats, inclusive of all life stages, include: roads and railroads; water diversions and impoundments; residential and commercial development; and severe weather patterns. CCC coho salmon population viability threats of lesser severity or extent include: channel modification; livestock farming and ranching; agriculture; logging and wood harvesting; fire, fuel management, and fire suppression; disease, predation, and competition; fishing and collecting; recreational areas and activities; mining; and hatcheries and aquaculture. Other emerging CCC coho salmon population viability threats include: water toxins, such as nutrients, pesticides, and pharmaceuticals; climate change; urbanization; adverse effects associated with the actual size of a population (e.g., small population dynamics); and increasing adverse impacts due to water diversions. (NMFS 2012a) The most significant threats discussed above that may be exacerbated by cannabis cultivation include: agriculture, water diversions and impoundments, channel modifications, land development, logging and wood harvesting, and existing roads and road development.

1.15 South-Central California Coast Steelhead

1.15.1 Status and Distribution

The South-Central California Coast (SCCC) steelhead DPS is a special-status species listed as threatened under the federal ESA (CDFW 2017b). The SCCC steelhead DPS includes steelhead populations in watersheds from the Pajaro River, located at the boundary between Santa Cruz and Monterey Counties, south to Arroyo Grande Greek, located in San Luis Obispo County (Figure 3).

1.15.2 Life History

In general, SCCC steelhead rear in freshwater for one to three years, migrate to the ocean to spend one to four years maturing in the marine environment, and return to freshwater to spawn. SCCC steelhead adult migration and spawning typically occurs during winter and early spring, and is cued by factors such as higher runoff and breaching of sandbars that form at the mouths of rivers during periods of low streamflows. SCCC steelhead may migrate back to the marine environment after spawning and return to freshwater to spawn again in subsequent years. Some large SCCC steelhead adults, however, may remain in freshwater after spawning and become trapped in deep residual pools in the summer. (NMFS 2013)

SCCC steelhead eggs incubate in redds for three weeks up to two months, depending on water temperature and dissolved oxygen conditions. Upon hatching, the alevins remain in redds for an additional two to six weeks before emerging into the water column as fry. Fry and juvenile SCCC steelhead typically spend a total of one to three years rearing in freshwater before out-migrating to the ocean in late winter and spring, cued by photoperiod, streamflow, temperature, and breaching of the sandbar. During their first rearing summer, juvenile SCC steelhead retreat to the cooler temperatures of headwaters or lagoons/estuaries[10]. At age one, juvenile SCCC steelhead that have grown rapidly, usually due to lagoon rearing, undergo smoltification and migrate out to the ocean. However, the majority of age one SCCC steelhead will stay in the river system and, in summer, again seek thermal refugia (primarily in headwaters), before finally out-migrating to the ocean at age two or three. In some watersheds, juvenile SCCC steelhead may rear in a lagoon or estuary for several weeks or months prior to entering the ocean. Following outmigration, SCCC steelhead spend between one and four years in the marine environment before migrating back to freshwater to spawn. (NMFS 2013)

1.15.3 Threats to Viability

SCCC steelhead are subject to a number of population viability is threats. The highest severity and most extensive SCCC steelhead threats include dams and surface water diversions, groundwater extraction, levees and channelization, recreational facilities, urban development, roads and culverts (and other passage barriers), agricultural development, non-point source pollution, and mining. SCCC steelhead population viability threats of low and medium severity include agricultural effluent, flood control/maintenance, non-native species, roads, upslope/upstream activities, urban effluents, and wildfires. (NMFS 2013) The most significant threats discussed above that may be exacerbated by cannabis cultivation include: dams and surface water diversions, groundwater extraction, agricultural development, passage barriers including culverts and road crossings, non-point source pollution, and agricultural effluent.

[10] Those steelhead that primarily rear over summer in lagoons or estuaries are termed lagoon-anadromous steelhead, while those primarily over-summering in freshwater rivers and streams are termed fluvial-anadromous steelhead. Finer-scale habitat switching, such as multiple movements between lagoon and freshwater habitats, is also possible. (NMFS 2013).

1.16 Southern California Coast Steelhead

1.16.1 Status and Distribution

The Southern California Coast (SCC) steelhead DPS is a special-status species listed as endangered under the federal ESA and not listed under the California ESA (CDFW 2017b). The SCC steelhead DPS includes Southern California coastal steelhead populations, including coastal steelhead populations between the Santa Maria River watershed and the Tijuana River watershed (Figure 3).

1.16.2 Life History

The SCC steelhead DPS exhibits a very similar life history to the SCCC steelhead DPS described above, under the South-Central California Coast Steelhead section. The only notable distinction in the life history description of the SCC steelhead as compared with SCCC steelhead is that SCC steelhead typically mature in the marine environment for two to four years, whereas SCCC steelhead reside in the marine environment for one to four years. (NMFS 2012b)

1.16.3 Threats to Viability

SCC steelhead face a number of population viability threats. The highest severity and most extensive SCC steelhead population viability threats include dams and surface water diversions, wildfires, groundwater extraction, urban development, levees and channelization, passage barriers (including culverts and road crossings), flood control maintenance, roads, agricultural development, recreational facilities, and non-native species. SCC steelhead population viability threats of low and medium severity include agricultural effluent, passage barriers associated with culverts and road crossings, urban effluents, mining and quarrying (including historical mining and quarrying), and upslope/upstream activities. (NMFS 2012b) The most significant threats discussed above that may be exacerbated by cannabis cultivation include: dams and surface water diversions, groundwater extraction, agricultural development, passage barriers including culverts and road crossings, existing roads and road development, and agricultural effluent.

2.0 Other Salmonids of Interest

Not included in Section 1.0 of this appendix are two anadromous salmonid populations considered by CDFW as likely to warrant designation as species of special concern, pink and chum salmon, and one special-status amphidromous salmonid, the coastal cutthroat trout. The Cannabis Cultivation Policy (Policy) is anticipated to be protective of pink salmon, chum salmon, and coastal cutthroat trout due to the similar means by which cannabis cultivation is expected to impact these populations and those that were reviewed in greater detail in Section 1.0 of this appendix.

2.1 Pink and Chum Salmon

Pink salmon and chum salmon are not listed as species of special concern by CDFW due to the insufficient information available to determine their status. However, both species' persistence in California is likely at risk due to their naturally small populations in the state and the fact that California represents the southern extreme of both of their ranges. Pink salmon have been observed in small numbers in the Klamath River, Russian River, Garcia River, Ten Mile River, Sacramento River and tributaries, and San Lorenzo River; they are currently extremely rare in California. Chum salmon are also rare; they seem to maintain small runs in northern California rivers (Smith, Klamath, and Trinity) and have been observed in freshwater as far south as the San Lorenzo River. Both species venture no further than 200 km inland from the ocean, have short freshwater residencies, and are heavily dependent on estuaries during the juvenile life stage. Impacts to estuaries and spawning areas from logging, road building, mining and other factors likely contribute to the species decline. (Moyle et al. 2015, 1995; Moyle 2002) These impacts may be exacerbated by cannabis cultivation.

2.2 Coastal Cutthroat Trout

Coastal cutthroat trout do not exhibit a strictly anadromous life history. Instead, individuals of this subspecies of cutthroat trout exhibit one of four life history variants: the amphidromous life history, the riverine (potadromous) life history, the stream-resident life history, and the lacustrine life history. Individuals exhibiting the amphidromous life history (the variant most similar to an anadromous life history) move back and forth between fresh and salt water multiple times to feed and then migrate to freshwater to spawn. Individuals exhibiting the potadromous life history strategy live in rivers and make seasonal migrations upstream and downstream. Stream-resident populations remain in streams and are often present in headwaters above natural barriers. Lacustrine coastal cutthroat trout dwell in large lakes but may migrate into streams to spawn. (Moyle et al. 2015)

Coastal cutthroat trout are distributed in California from the Salt River, tributary to the Eel River estuary, north to the California-Oregon border. They typically spawn and rear in small streams until one year of age. After year one, juveniles may move extensively throughout the watershed but prefer small, low gradient coastal streams and estuaries/lagoons where they may spend months at a time, moving in and out of freshwater. Those individuals that migrate to salt water typically stay near shore, venturing no more than 7 kilometers from the coastline and often remaining close to the plume of the river in which they reared. (Moyle et al. 2015)

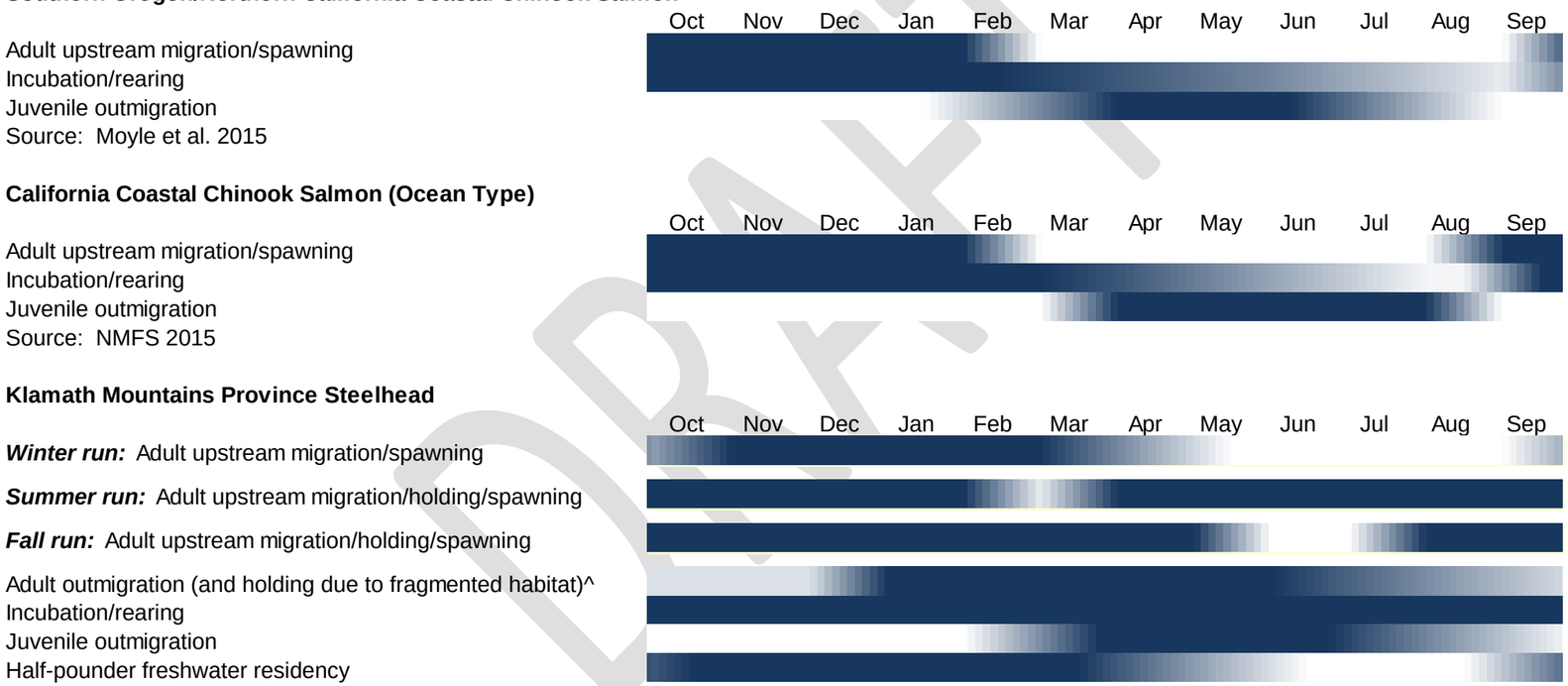
Like many of special-status anadromous salmonids discussed in detail in this Policy (Appendix B, section 1.0), coastal cutthroat trout experience impacts from land-use activities, including agriculture, grazing, logging, water diversion, rural and urban development, estuary alteration, and road construction; fish passage issues, such as major dams; and competition and hybridization with hatchery steelhead. Climate change is expected to further stress the

population of coastal cutthroat trout in California. (Moyle et al. 2015) These impacts may be exacerbated by cannabis cultivation.

Figure 1. Life-Stage Timing of California Special-Status Anadromous Salmonids

Shading indicates the relative abundance of "survivors" (i.e., individuals who persist through the conclusion of that life stage category) present in freshwater, unless otherwise specified, by life stage category and ESU/DPS/DTE. Life stage categories are consecutive (e.g., when a juvenile salmonid commences outmigration, it is represented by an addition to the "Juvenile outmigration" category and a loss from the "Incubation/rearing" category). The darkest shading indicates the highest abundance of survivors within a life stage category by ESU/DPS/DTE. No shading indications that no individuals within the life stage category are expected to be present under most circumstances.

These graphics are approximations of the timing of salmonid life stages by ESU/DPS/DTE and are subject to the constraints of the various source materials. These graphics should not be relied upon as independent sources; instead, the in-text life history summaries, and the sources provided therein, should be referenced.



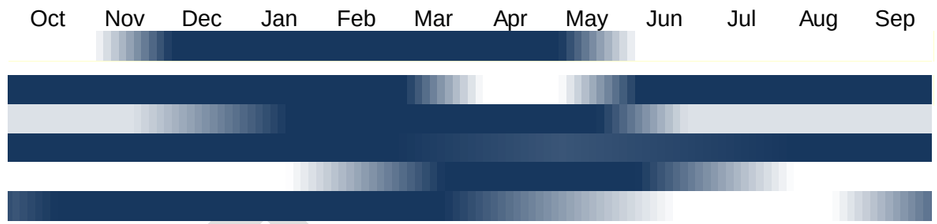
^ The timing of adult outmigration is infrequently described in the source materials, therefore, graphical representations of adult outmigration frequently show best estimates of the timing of this life stage based on the timing of spawning, the local hydrologic regime, and extrapolations from similar populations.

Figure 1. Continued

Northern California Steelhead

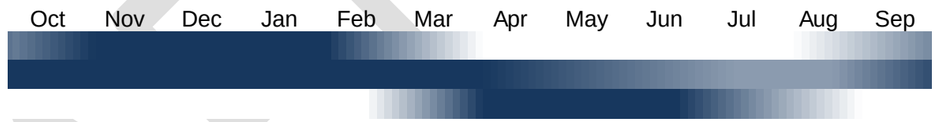
Winter run: Adult upstream migration/spawning

Summer run: Adult upstream migration/holding/spawning
Adult outmigration (and holding due to fragmented habitat)^
Incubation/rearing
Juvenile outmigration
Half-pounder freshwater residency
Source: NMFS 2015



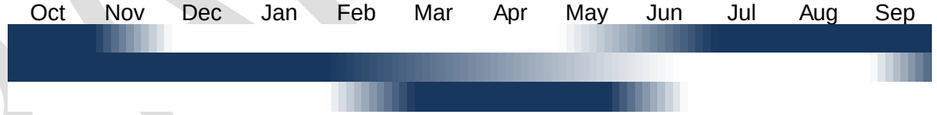
Southern Oregon/Northern California Coast Coho Salmon

Adult upstream migration/spawning
Incubation/rearing
Juvenile outmigration
Source: NMFS 2014a



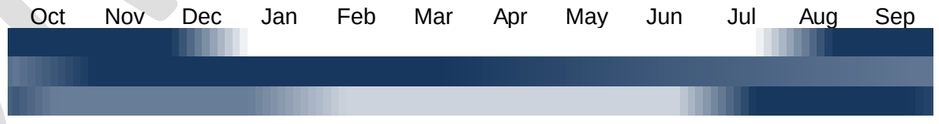
Upper Klamath-Trinity Rivers Spring-Run Chinook Salmon

Adult upstream migration/holding/spawning
Incubation/rearing
Juvenile outmigration
Source: Moyle et al. 2015



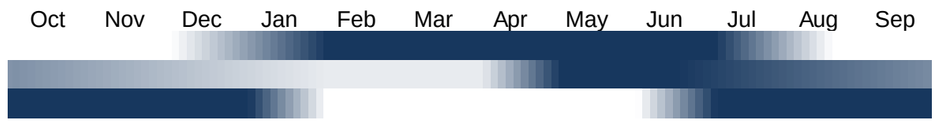
Upper Klamath-Trinity Rivers Fall-Run Chinook Salmon

Adult upstream migration/spawning
Incubation/rearing
Juvenile outmigration
Source: Moyle et al.



Sacramento River Winter-Run Chinook Salmon

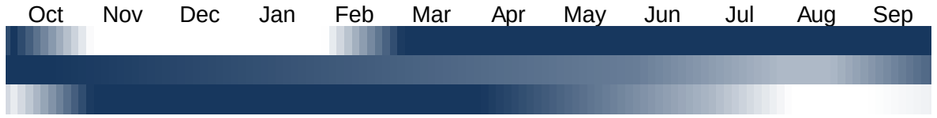
Adult upstream migration/holding/spawning
Incubation/rearing
Juvenile outmigration (through Sacramento River)
Source: CDFW 2015, NMFS 2014b



^ The timing of adult outmigration is infrequently described in the source materials, therefore, graphical representations of adult outmigration frequently show best estimates of the timing of this life stage based on the timing of spawning, the local hydrologic regime, and extrapolations from similar populations.

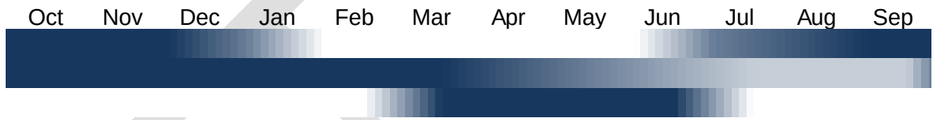
Figure B-1 Continued

Central Valley Spring-Run Chinook Salmon



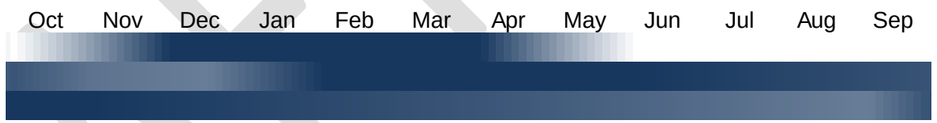
Adult upstream migration/holding/spawning
Incubation/rearing
Juvenile outmigration
Source: CDFW 2015, NMFS 2014b

Central Valley Fall-Run Chinook Salmon



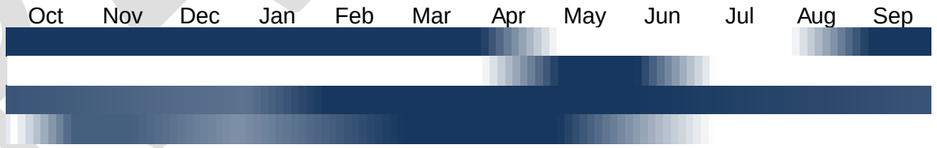
Adult upstream migration/spawning*
Incubation/rearing
Juvenile outmigration*
Source: Moyle et al. 2015

Central Valley Late Fall-Run Chinook Salmon



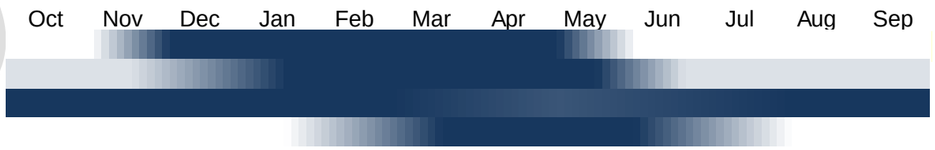
Adult upstream migration/spawning*
Incubation/rearing
Juvenile outmigration*
Source: Moyle et al. 2015

California Central Valley Steelhead



Adult upstream migration/spawning
Adult outmigration
Incubation/rearing
Juvenile outmigration
Source: CDFW 2015, NMFS 2014b

Central California Coast Steelhead



Adult upstream migration/spawning
Adult outmigration (and holding due to fragmented habitat)^
Incubation/rearing
Juvenile outmigration
Source: NMFS 2007a, 2015

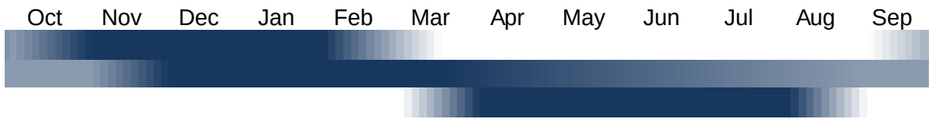
^ The timing of adult outmigration is infrequently described in the source materials, therefore, graphical representations of adult outmigration frequently show best estimates of the timing of this life stage based on the timing of spawning, the local hydrologic regime, and extrapolations from similar populations.

* Representation of life stage timing includes presence in freshwater and brackish water (i.e., the San Francisco Bay/Sacramento-San Joaquin Delta).

Figure B-1 Continued

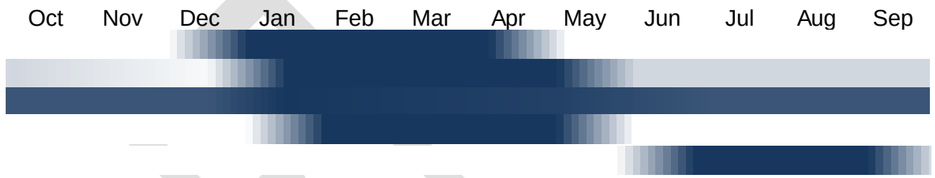
Central California Coast Coho Salmon

Adult upstream migration/spawning
Incubation/rearing
Juvenile outmigration
Source: NMFS 2012a



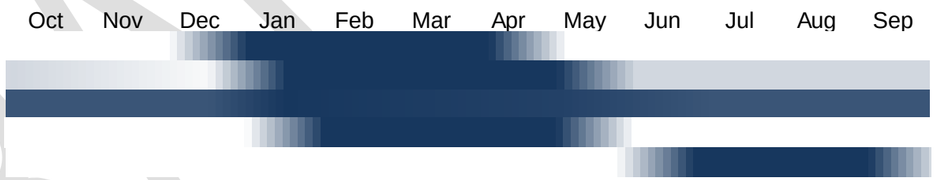
South-Central California Coast Steelhead

Adult upstream migration/spawning
Adult outmigration (and holding due to fragmented habitat)^
Incubation/rearing
Juvenile outmigration
Lagoon rearing
Source: NMFS 2013

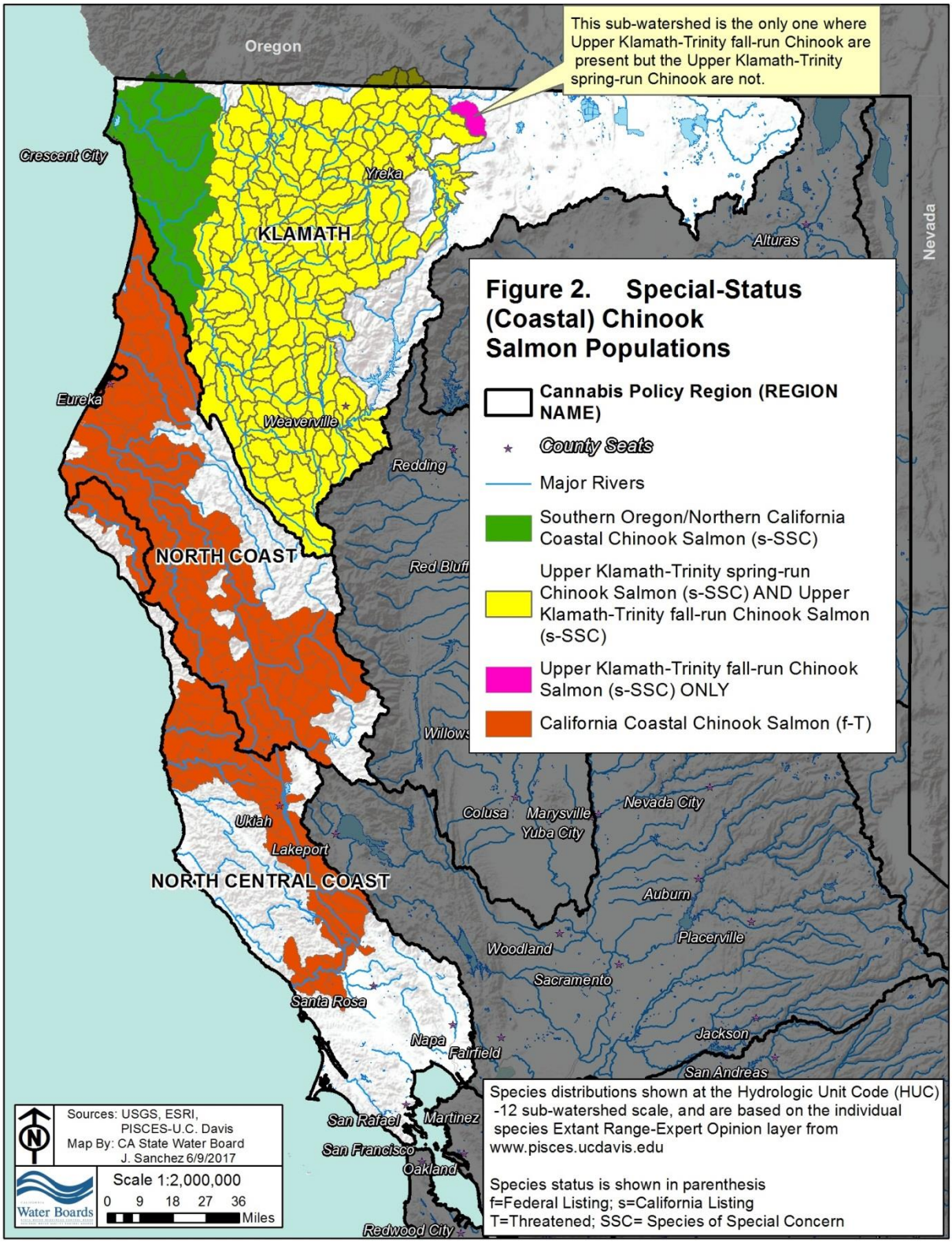


Southern California Coast Steelhead

Adult upstream migration/spawning
Adult outmigration (and holding due to fragmented habitat)^
Incubation/rearing
Juvenile outmigration
Lagoon rearing
Source: NMFS 2012b



^ The timing of adult outmigration is infrequently described in the source materials, therefore, graphical representations of adult outmigration frequently show best estimates of the timing of this life stage based on the timing of spawning, the local hydrologic regime, and extrapolations from similar populations.


This sub-watershed is the only one where Upper Klamath-Trinity fall-run Chinook are present but the Upper Klamath-Trinity spring-run Chinook are not.
Oregon
Crescent City
Yreka
KLAMATH
Alturas
Nevada
Eureka
Weaverville
Redding
NORTH COAST
Red Bluff
Willows
Figure 2. Special-Status (Coastal) Chinook Salmon Populations
Cannabis Policy Region (REGION NAME)
County Seats
Major Rivers
Southern Oregon/Northern California Coastal Chinook Salmon (s-SSC)
Upper Klamath-Trinity spring-run Chinook Salmon (s-SSC) AND Upper Klamath-Trinity fall-run Chinook Salmon (s-SSC)
Upper Klamath-Trinity fall-run Chinook Salmon (s-SSC) ONLY
California Coastal Chinook Salmon (f-T)
Colusa
Marysville
Yuba City
Nevada City
Ukiah
Lakeport
NORTH CENTRAL COAST
Auburn
Placerville
Woodland
Sacramento
Santa Rosa
Napa
Fairfield
Jackson
San Andreas
San Rafael
Martinez
San Francisco
Oakland
Redwood City
Sources: USGS, ESRI, PISCES-U.C. Davis
Map By: CA State Water Board J. Sanchez 6/9/2017
Scale 1:2,000,000
0 9 18 27 36 Miles
Water Boards
Species distributions shown at the Hydrologic Unit Code (HUC) -12 sub-watershed scale, and are based on the individual species Extant Range-Expert Opinion layer from www.pisces.ucdavis.edu
Species status is shown in parenthesis
f=Federal Listing; s=California Listing
T=Threatened; SSC= Species of Special Concern

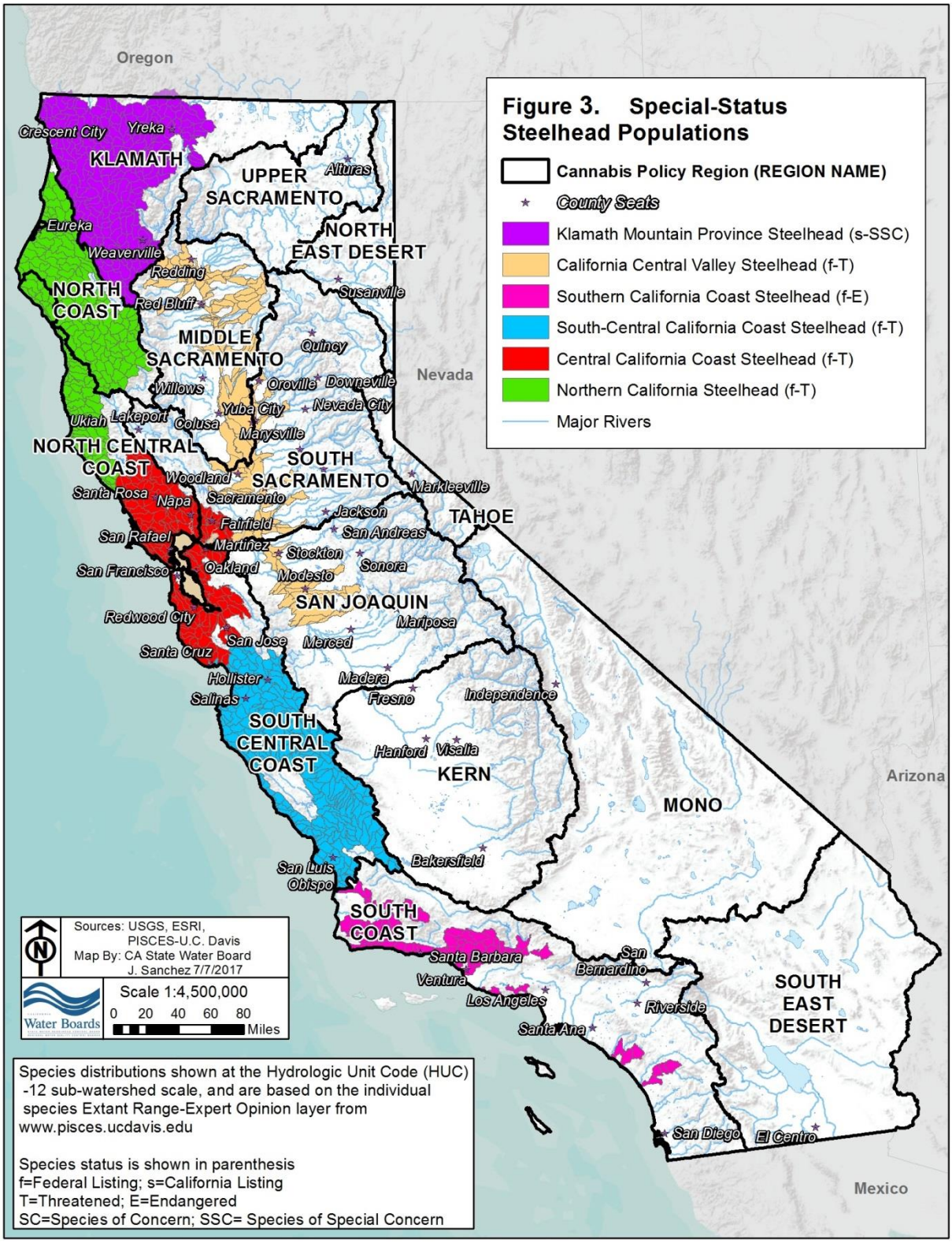
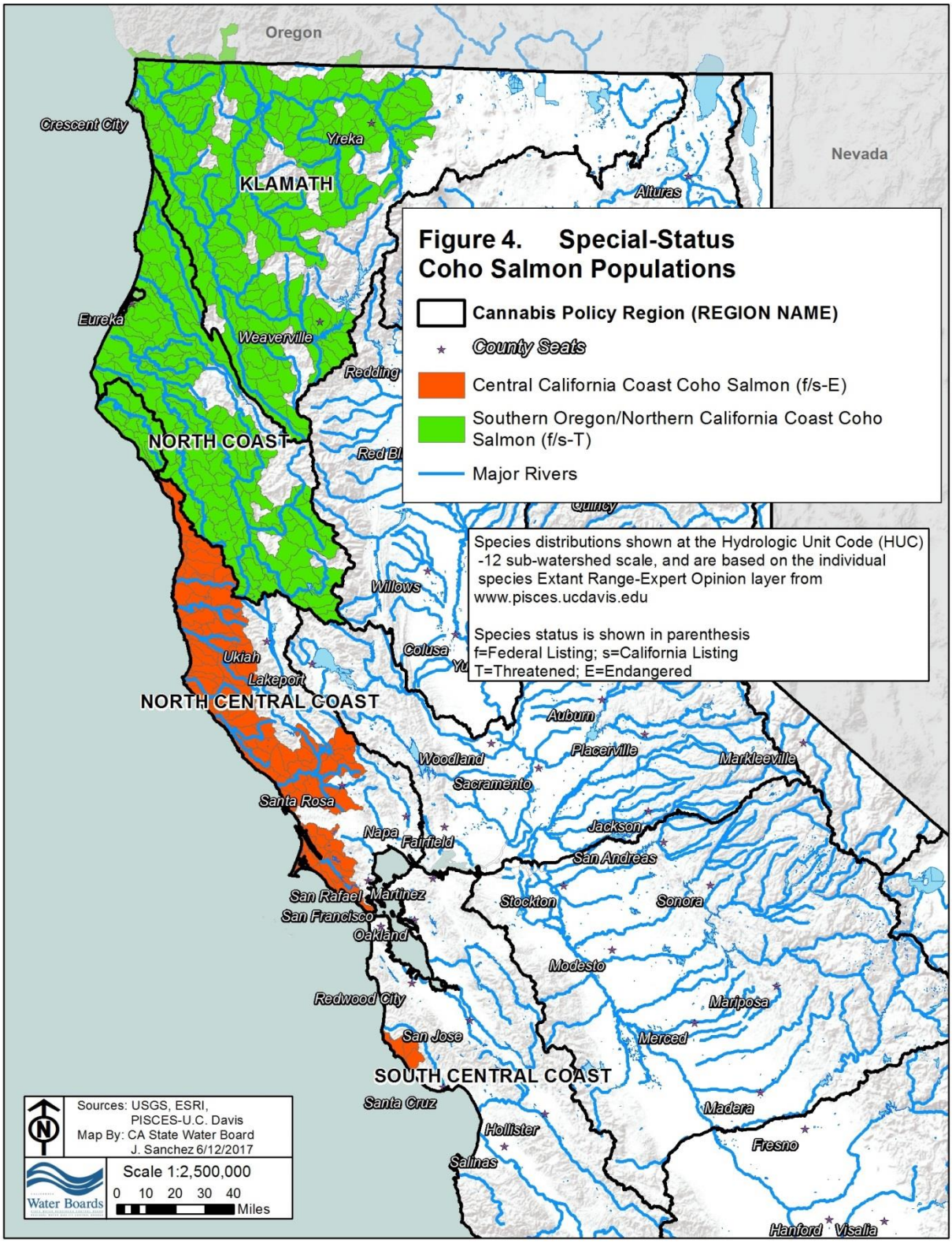


Figure 3. Special-Status Steelhead Populations
Cannabis Policy Region (REGION NAME)
County Seats
Klamath Mountain Province Steelhead (s-SSC)
California Central Valley Steelhead (f-T)
Southern California Coast Steelhead (f-E)
South-Central California Coast Steelhead (f-T)
Central California Coast Steelhead (f-T)
Northern California Steelhead (f-T)
Major Rivers
Oregon
Nevada
Arizona
Mexico
KLAMATH
UPPER SACRAMENTO
NORTH EAST DESERT
NORTH COAST
MIDDLE SACRAMENTO
NORTH CENTRAL COAST
SOUTH SACRAMENTO
TAHOE
SAN JOAQUIN
SOUTH CENTRAL COAST
KERN
MONO
SOUTH COAST
SOUTH EAST DESERT
Crescent City
Yreka
Eureka
Weaverville
Redding
Red Bluff
Alturas
Susanville
Quincy
Willows
Oroville
Downieville
Yuba City
Nevada City
Ukiah
Lakeport
Colusa
Marysville
Woodland
Santa Rosa
Napa
Sacramento
Markleeville
Jackson
Fairfield
San Andreas
San Rafael
Martinez
Stockton
Oakland
Modesto
Sonora
San Francisco
Redwood City
Mariposa
San Jose
Merced
Santa Cruz
Hollister
Madera
Fresno
Independence
Salinas
Hanford
Visalia
Bakersfield
San Luis Obispo
Santa Barbara
Ventura
Los Angeles
San Bernardino
Riverside
Santa Ana
San Diego
El Centro
Sources: USGS, ESRI, PISCES-U.C. Davis
Map By: CA State Water Board J. Sanchez 7/7/2017
Scale 1:4,500,000
0 20 40 60 80 Miles
Water Boards
Species distributions shown at the Hydrologic Unit Code (HUC) -12 sub-watershed scale, and are based on the individual species Extant Range-Expert Opinion layer from www.pisces.ucdavis.edu
Species status is shown in parenthesis
f=Federal Listing; s=California Listing
T=Threatened; E=Endangered
SC=Species of Concern; SSC= Species of Special Concern


Oregon
Nevada
Crescent City
Yreka
KLAMATH
Alturas
Eureka
Weaverville
Redding
NORTH COAST
Red Bl
Quincy
Willows
Colusa
Ukiah
Lakeport
NORTH CENTRAL COAST
Auburn
Placerville
Markleeville
Woodland
Sacramento
Santa Rosa
Napa
Fairfield
Jackson
San Andreas
San Rafael
Martinez
San Francisco
Oakland
Stockton
Sonora
Modesto
Redwood City
Mariposa
San Jose
Merced
SOUTH CENTRAL COAST
Santa Cruz
Madera
Hollister
Fresno
Salinas
Hanford
Visalia
Figure 4. Special-Status Coho Salmon Populations
Cannabis Policy Region (REGION NAME)
County Seats
Central California Coast Coho Salmon (f/s-E)
Southern Oregon/Northern California Coast Coho Salmon (f/s-T)
Major Rivers
Species distributions shown at the Hydrologic Unit Code (HUC) -12 sub-watershed scale, and are based on the individual species Extant Range-Expert Opinion layer from www.pisces.ucdavis.edu
Species status is shown in parenthesis
f=Federal Listing; s=California Listing
T=Threatened; E=Endangered
Sources: USGS, ESRI, PISCES-U.C. Davis
Map By: CA State Water Board J. Sanchez 6/12/2017
Scale 1:2,500,000
0 10 20 30 40
Miles
Water Boards

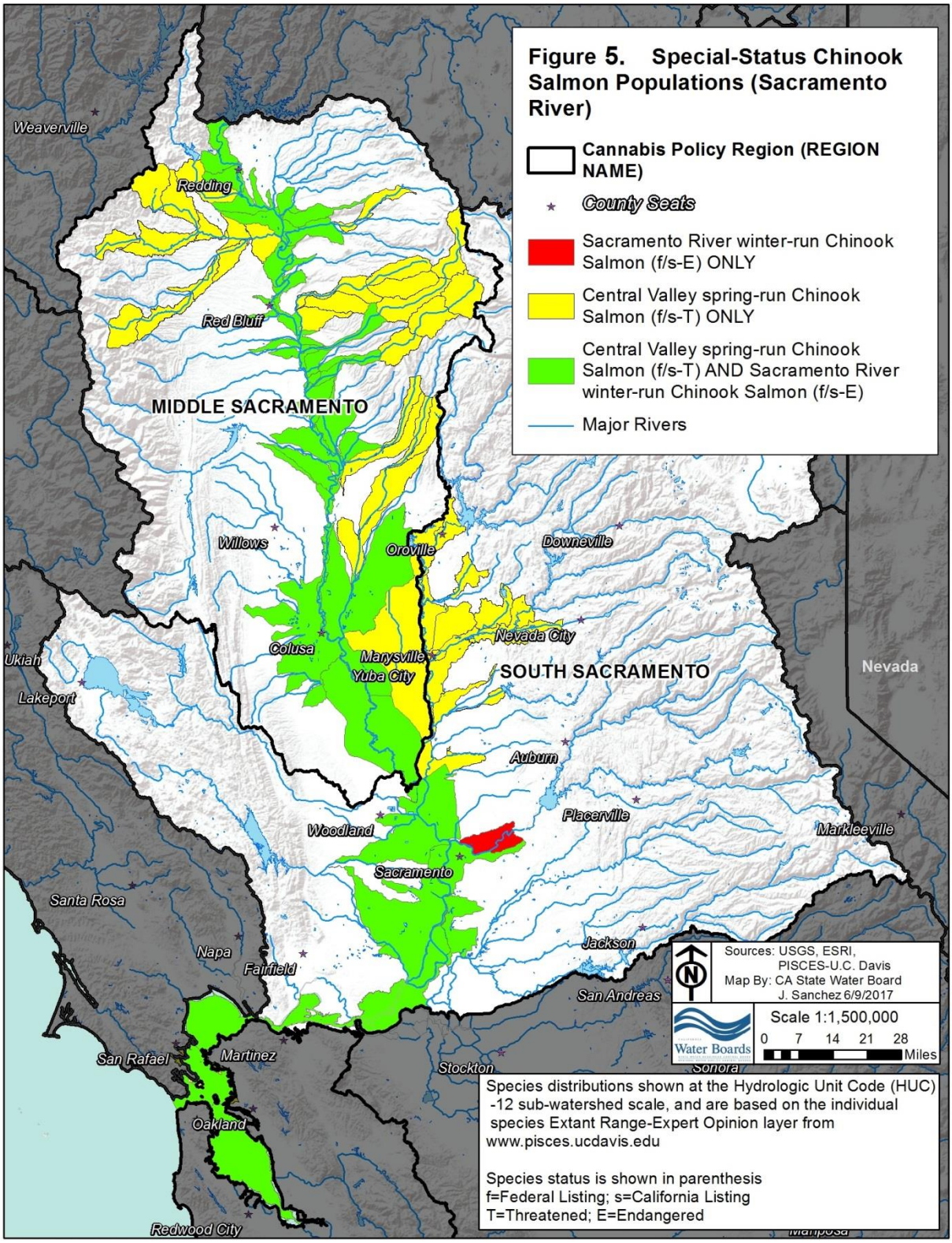


Figure 5. Special-Status Chinook Salmon Populations (Sacramento River)
Cannabis Policy Region (REGION NAME)
County Seats
Sacramento River winter-run Chinook Salmon (f/s-E) ONLY
Central Valley spring-run Chinook Salmon (f/s-T) ONLY
Central Valley spring-run Chinook Salmon (f/s-T) AND Sacramento River winter-run Chinook Salmon (f/s-E)
Major Rivers
MIDDLE SACRAMENTO
SOUTH SACRAMENTO
Weaverville
Redding
Red Bluff
Willows
Oroville
Downeville
Nevada City
Colusa
Marysville
Yuba City
Ukiah
Lakeport
Auburn
Placerville
Markleeville
Woodland
Sacramento
Santa Rosa
Napa
Fairfield
Jackson
San Andreas
San Rafael
Martinez
Stockton
Oakland
Redwood City
Nevada
Sources: USGS, ESRI, PISCES-U.C. Davis
Map By: CA State Water Board J. Sanchez 6/9/2017
Scale 1:1,500,000
0 7 14 21 28 Miles
Water Boards
Species distributions shown at the Hydrologic Unit Code (HUC) -12 sub-watershed scale, and are based on the individual species Extant Range-Expert Opinion layer from www.pisces.ucdavis.edu
Species status is shown in parenthesis
f=Federal Listing; s=California Listing
T=Threatened; E=Endangered

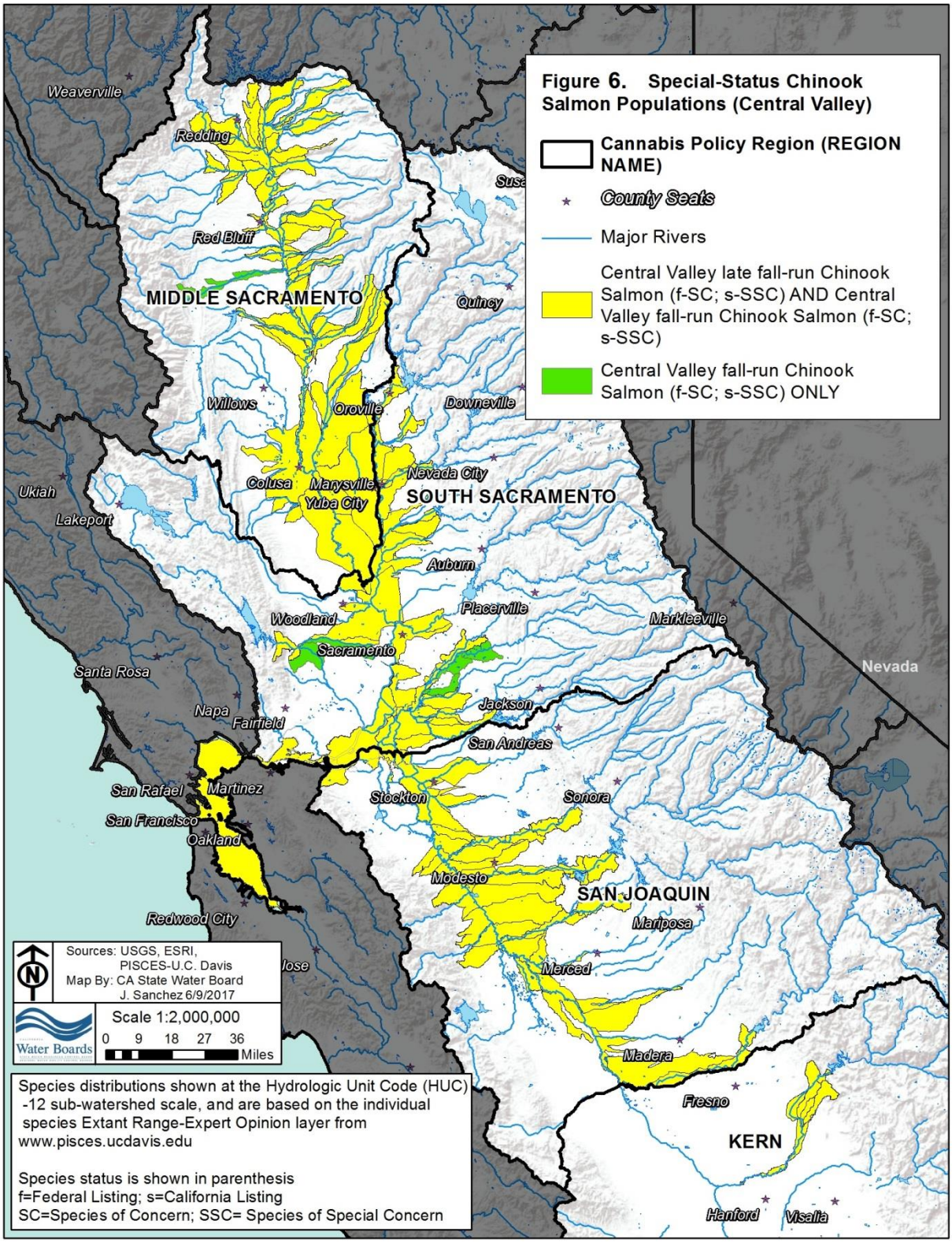


Figure 6. Special-Status Chinook Salmon Populations (Central Valley)
Cannabis Policy Region (REGION NAME)
County Seats
Major Rivers
Central Valley late fall-run Chinook Salmon (f-SC; s-SSC) AND Central Valley fall-run Chinook Salmon (f-SC; s-SSC)
Central Valley fall-run Chinook Salmon (f-SC; s-SSC) ONLY
MIDDLE SACRAMENTO
SOUTH SACRAMENTO
SAN JOAQUIN
KERN
Weaverville
Redding
Red Bluff
Willows
Oroville
Quincy
Downeville
Nevada City
Colusa
Marysville
Yuba City
Ukiah
Lakeport
Auburn
Placerville
Markleeville
Woodland
Sacramento
Santa Rosa
Napa
Fairfield
Jackson
San Andreas
San Rafael
Martinez
Stockton
Sonora
San Francisco
Oakland
Modesto
Mariposa
Redwood City
Merced
Madera
Fresno
Hanford
Visalia
Nevada
Sources: USGS, ESRI, PISCES-U.C. Davis
Map By: CA State Water Board J. Sanchez 6/9/2017
Scale 1:2,000,000
0 9 18 27 36 Miles
Water Boards
Species distributions shown at the Hydrologic Unit Code (HUC) -12 sub-watershed scale, and are based on the individual species Extant Range-Expert Opinion layer from www.pisces.ucdavis.edu
Species status is shown in parenthesis
f=Federal Listing; s=California Listing
SC=Species of Concern; SSC= Species of Special Concern

PBarnes.SAzzimonti 10/12/17

S:\DWR\VOL1\WQC-PT\Cannabis\Interim Policy\Final Draft Policy and Staff Report\Final Policy and Staff Report\Final Staff Report/Final Appendix_2 Salmonid Life Histories